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Nesting Giant Canada Geese in Western South Dakota

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NESTING GIANT CANADA GEESE

IN WESTERN SOUTH DAKOTA

BY

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NESTING GIANT CANADA GEESE

IN WESTERN SOUTH DAKOTA

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable for meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Thesis Advisor

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DMS

NESTING GIANT CANADA GEESE IN

WESTERN SOUTH DAKOTA

Abstract

DOYLE M. STIEFEL

Giant Canada geese (Branta canadensis maxima) began nesting on 27 March 1976 and 2 April 1977. Peak hatch occurred from 15 to 21 May 1976 and 22 to 28 May 1977 and the nesting season lasted 69 days in 1976 and 83 days in 1977.

Average clutch size was 4.8 eggs per nest in 1976 and 5.0 in 1977. Thirty-three percent of all eggs observed in 1976 and 23% in 1977 failed to hatch. Infertility and desertion were the main reasons that eggs did not hatch.

Seventy percent of the territorial pairs in 1976 and 41% in 1977 nested. Nesting success was 76% in 1976 and 79% in 1977. Mean brood size was 4.6 in 1976 and 4.7 in 1977.

The estimated number of geese in the study area in 1977 was 1196 of which 573 were territorial pairs (0.5 geese per section). Approximately 3.7 goslings per breeding pair in 1976 and 3.5 goslings in 1977 survived through the flight stage.

Thirty variables were analyzed using a discriminant function analysis to evaluate goose nesting habitat on stockponds. Size, headwater development, presence of an island, permanence of the pond and disturbance by livestock accounted for 52% of the variation between ponds used and ponds not used by geese.

Stockponds were assigned to 1 of 4 habitat classes with Class 4 representing optimal goose nesting habitat. Size, headwater development, percent basin water, density of surrounding vegetation, distance to nearest farmstead, and southward drainage were the 6 variables which best separated the 4 classes of ponds.

When "class" and the other 30 variables were entered into the analysis the presence or absence of geese on stockponds was predicted by the computer with 92% and 93% accuracy, respectively.

A total of 2674 stockponds was estimated for the study area of which 1390 (52%) ponds were considered to have potential as goose nesting habitat.

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INTRODUCTION

In 1962 the South Dakota Department of Game, Fish and Parks initiated a program to restore populations of giant Canada geese (*Branta canadensis maxima*) in eastern South Dakota (Kuck 1971). Four years later through the maintenance of captive flocks, land-owner-cooperator programs and the release of free-flying birds, the program was enlarged to include western South Dakota (Kuck 1975, Lengkeek 1973).

As the population of geese expanded a census technique to estimate population numbers was necessary. Time, money and labor were factors to be considered. Smith and Hawkins (1948) stated that waterfowl management requires an accurate inventory of the waterfowl from year to year.

Habitat requirements of breeding pairs of Canada geese have been qualitatively described by many authors (Williams and Sooter 1940, Williams and Marshall 1937, Hanson and Eberhardt 1971, McCarthy 1973). Few studies have provided a quantitative measure of habitat requirements. Klebenow (1969), James (1971), and Crawford and Bolen (1976) used statistical techniques to quantitatively measure and evaluate habitat conditions for different species of birds. Kaminski and Prince (1977) used a stepwise discriminant function analysis to evaluate habitat conditions for breeding pairs of geese in Michigan. Geis (1956) stated that the lack of preferred nesting habitat may limit the number of breeding pairs of geese in an area.

The objectives of this study were to estimate (1) size of the population and production of the giant Canada goose flock on the study area in western South Dakota and (2) the amount of nesting habitat available to the goose flock.

DESCRIPTION OF STUDY AREA

The 6685 km^2 study area in western South Dakota included portions of Haakon, Jackson, and Pennington counties (Fig. 1). Major land uses were livestock grazing and crop production.

Baumberger (1977) described soils in the area as formed mainly from clayey or silty shales on uplands. Soils were deep to shallow clayey soils in the southern portion and soft silty to clayey in the Badlands. The remainder of the area originated from deep to shallow soils of clayey and loamy nature.

Major vegetation was described by Baumberger (1977) as wheatgrass-grama grass prairie. Key species of grass were western wheatgrass (Agropyron smithii), green-needle grass (Stipa viridula), and blue grama (Bouteloua gracilis) with buffalograss (Buchloe dactyloides) and sideoats grama (Bouteloua curtipendula) more prevalent in the basins of the Badlands.

Prairie threeawn (Aristida cristata), blue grama, buffalograss, prickly pear (Opuntia polyacantha), fringed sagewort (Artemesia frigida), and threadleaf sedge (Carex filifolia) increased with range deterioration. Japanese brome (Bromus japonicus) and curly-cup gumweed (Grindelia squarrosa) were common invaders.

The climate was continental with temperatures ranging from -28 C in the winter to 38 C in the summer. Average annual precipitation was 38.43 cm of which 30.33 cm (79%) fell during the growing season.

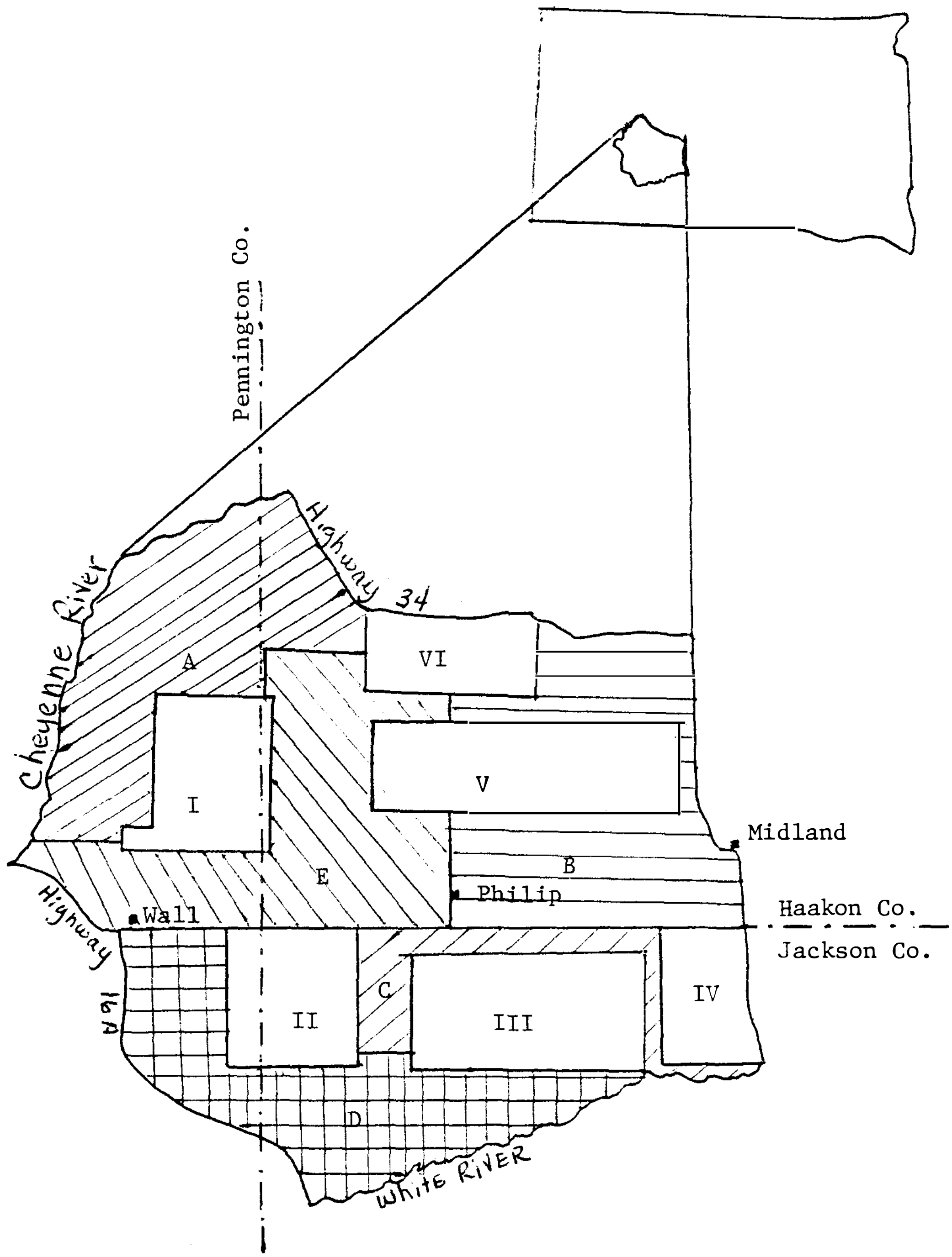

Figure 1. The study area and strata used to estimate parameters of the giant Canada goose population in western South Dakota, 1976-1977. The areas designated by Roman numerals and capital letters represent strata which were randomly sampled.

Snowfall averaged 60.96 cm annually with a variation from 17.87 cm to 147.32 cm.

Average annual evaporation rate from a Weather Bureau Class A pan for the area was 139.7 cm of which 109.2 cm (79%) evaporated from May through October. Average annual lake evaporation was 99.06 cm.

Weather data were obtained from Climatological Summary Number 14 prepared by Department of Agricultural Engineering, South Dakota State University, Brookings. Data were collected at the SDSU Experiment Station located 1 mile east of Cottonwood, South Dakota.

METHODS

A stratified random sample was used to estimate population size and production of the Canada goose flock. Brewster et al. (1976), Stewart and Kantrud (1972 and 1974), and Kaminski and Parker (1975) used a stratified random sample to estimate waterfowl populations. A stratified random sample may reduce variability in samples without increasing sample size or cost (Rutherford and Hayes 1976).

A portion of study area was stratified into 6 concentration areas based on the locations of all nests found in 1975 (Fig. 1). Nesting outside these areas was minimal as reported by Lengkeek (1973) and Bultsma (1976). The 6 concentration areas (1016 sections) were designated as Strata I, II, III, IV, V, VI and were 204, 168, 220, 96, 208, and 120 land-survey sections in size, respectively.

Pairs of geese were observed nesting outside the 6 strata in 1976 and 5 additional strata were used in 1977 to sample the study area. Boundaries were drawn based on physiographic differences in landscape to provide homogeniety among the sections in each strata. The 5 strata (1563 sections) were designated as A, B, C, D, E and were 383, 401, 154, 258, and 367 sections in size, respectively (Fig. 1).

Basic sampling unit was 1 land-survey section (2.59 km2). A sample of random sections for each strata was selected using a random numbers table. Approximately 15% of the initial 6 strata and 10% of the remaining 5 strata were sampled based on available manpower. A total of 301 sections was selected.

Nest Observations

Nest searching began on 10 April 1976 and 20 April 1977 approximately 7 to 10 days after the first nesting attempts by geese on the study area. Searching efforts were delayed to allow nest establishment and increase the probability of finding the nesting pair of geese at the nest site. Williams and Marshall (1937) noted that in early stages of nest establishment pairs of geese frequently remained away from the nest. Each stockpond was observed from a distance using a 20X spotting scope to locate nesting pairs and individual geese. Geese which were paired and isolated from other geese or defending a nest site were designated as territorial pairs. Hanson and Browning (1959) defined territorial pairs as pairs of geese that were observed to be closely associated with a small area and retained their identity in relation to other geese. The presence of 3 geese was considered 1 pair and 1 single, since yearling geese may return with their parents in the spring during nest establishment (Sherwood 1967). Geese in groups of 5 or more were designated as singles and considered yearlings or non-breeding adults except when a pair was observed. Hanson and Browning (1959) classified small flocks of 3 or more geese as non-breeders.

Eggs were counted in each nest to determine clutch size. If goslings had left the nest egg shell membranes were counted. Unhatched eggs were broken to determine fertility. Nest initiation was computed by back calculation using a 28 day incubation period and 1.5 day interval for each egg layed (Kossack 1950).

Nesting Habitat Analysis

Thirty variables thought to influence use of a stockpond by nesting geese were measured and recorded in 1977 (Table 1). Variables chosen were based on previous nesting studies on Canada geese (McCarthy 1973, Bultsma 1976, Lengkeek 1973, Hanson 1965, Williams and Marshall 1937, Williams and Sooter 1940, Hanson and Eberhardt 1971, Kaminski and Prince 1977, Dow 1943, Miller and Collins 1953, and Klopman 1958) and by analyzing variables associated with stockponds used by geese during the 1976 nesting season.

Each stockpond was assigned to a class which indicated its potential as goose nesting habitat. Four classes were used with Class 4 representing optimal conditions for geese. This rating technique tested my ability to evaluate nesting habitat based on a review of literature and past experience.

Headwater development, an estimate of shoreline irregularity, was measured as a percentage of the stockpond area extending from the point where the stockpond began to narrow to the point where the surface water terminated at the headwater. An oval, circle, rectangle, or square stockpond had zero headwater development. Stockponds in which the surface water extended upstream into the drainage had positive values.

A discriminant function analysis (Nie et al. 1975) was used to analyze the data. Analysis was restricted to the data collected for Stratum I because it contained the largest population of geese and I assumed that most of the stockponds suitable for nesting in the stratum were used.

Table 1. List of variables used to evaluate goose nesting habitat on stockponds in western South Dakota, 1977.

SIZE	Size of stockpond
SULU	Landuse determined on a four-section cluster surrounding the random section
ADLU	Landuse on random section
SHVH	Shoreline vegetation height
SHVD	Shoreline vegetation density
SUVH	Height of upland vegetation surrounding the stockpond
SUVD	Density of upland vegetation surrounding the stockpond
SHEM	Percent shore with emergent cover
MAN	Disturbance by man
COW	Disturbance by livestock
BASIN	Water level expressed as percent stockpond basin capacity
OPEN	Percent of surface water void of emergent vegetation
ISLA	Number of islands present
PENN	Number of well defined peninsulas
MISHSL	Minimum slope of shorelines
MSAHSL	Maximum slope of shorelines
MIHOSL	Minimum slope from shoreline to horizon
MAHOSL	Maximum slope from shoreline to horizon
HEAD	Percent headwater development
DTFM	Distance to nearest farm
PERPD1	Represented permanent pond
PERPD2	Represented temporary pond
NORTH	Upstream direction associated with the stockpond
SOUTH	Upstream direction associated with the stockpond
EAST	Upstream direction associated with the stockpond
WEST	Upstream direction associated with the stockpond
NORTHEAST	Upstream direction associated with the stockpond
SOUTHEAST	Upstream direction associated with the stockpond
NORTHWEST	Upstream direction associated with the stockpond
SOUTHWEST	Upstream direction associated with the stockpond
CLASS	Habitat rating assigned to each stockpond

In the stepwise portion of the discriminant analysis Wilks' lambda was an indicative measure of the discriminating power in the variables. The discriminating variables were listed according to their ability to discriminate between the groups established in the data. Each variable was assigned a lambda value by the computer to indicate the proportion of variation unexplained after that variable was entered into the function. Thus the amount of information provided by 1 variable was measured by the percent decrease that it caused in Wilks' lambda.

A classification technique was another measure of "how well" the variables could separate the groups. Groups in this study referred to stockponds used by geese and stockponds not used by geese. The computer gave each stockpond a classification score based on the value of each variable measured for that stockpond. Each stockpond received a score for each group and was assigned to the group for which it obtained the highest score. Once that step was completed for all the stockponds, the computer compared its predicted group memberships to the actual group membership of the stockponds. The percentage of stockponds correctly classified indicated "how well" the variables could predict the use of the stockponds by geese.

RESULTS AND DISCUSSION

Nesting Phenology

The first nests observed were initiated on 27 March in 1976 and 2 April in 1977. Nest initiation in western South Dakota was reported by Lengkeek (1973) on 4 April 1970 and 1 April 1971 and by Bultsma (1976) on 1 April 1974 and 8 April 1975.

The largest number of nests initiated in 1 week (peak nesting) was 1 to 7 April in 1976 (15 known-fate nests) and 15 to 21 April in 1977 (19 known-fate nests). Variation between the 2 nesting seasons was believed to be due to low temperatures and storms in late March and early April. Bultsma (1976), Kaminski and Parker (1975), and Hanson and Browning (1959) reported that geese initiated nesting after a week of temperatures that averaged at least 5 C.

Temperatures remained above 5 C beginning 8 March 1976 with traces of snow through 13 April. In March 1977 temperatures fluctuated around 8 C but dropped to a low of -1 C and remained below 5 C through 5 April. Low temperatures in late March were accompanied by 3 cm of precipitation which constituted 49 percent of the total precipitation received in March. Kaminski and Parker (1975) found that winter storms delayed nesting by Canada geese in Michigan. Some nests were apparently initiated on the study area around 10 May 1977 as young broods (1 to 3 weeks old) were frequently observed during the first week in July.

The largest percentage of nests hatched from 15 to 21 May 1976 and from 22 to 28 May 1977 with the first observed hatch on 1 May 1976 and 6 May 1977 and the last hatch on 30 May 1976 and 24 June 1977. Lengkeek (1973) found that hatching extended from 7 May to 8 June in 1971 with the peak hatch occurring 8 to 14 May. Hatching began 15 May and ended 22 June 1975 with a peak occurring 15 to 21 May (Bultsma 1976).

Length of the nesting season was 69 days in 1976 and 83 days in 1977 and is similar to the 69 day season in 1971 (Lengkeek 1973) and the 70 day season in 1975 (Bultsma 1976). Klopman (1958) reported that the average length of nesting season for Canada geese varied from 53 days in Manitoba to 83 days in California.

Nests

In 1976, 6 of the nests in random sections were on shorelines, 8 on peninsulas, 10 on islands and 2 on artificial structures. In 1977, 10 of the nests were on shorelines, 11 on peninsulas, and 12 on islands.

In 1976, 26 nests contained 124 eggs for an average clutch size of 4.8 ± 0.3 (S.E.). Thirty-three nests observed in 1977 contained 166 eggs for an average clutch size of 5.0 ± 0.2 (S.E.) Difference between years was not significant ($P > 0.1$). These clutch sizes were similar to clutch sizes reported in other studies on Canada geese (Table 2).

Table 2. Summary of production studies on Canada geese in North America

Reference	Location	Clutch Size	Egg Success[b]	Nest Success[c]	Brood Size	Gosling Mortality (%)
Present Study	South Dakota	4.9	72	78	4.7	4[a]
Lengkeek (1973)	South Dakota	5.4	68	78	4.6	11
Bultsma (1976)	South Dakota	5.3	59	59	5.1	17
Kaminski and Parker (1975)	Michigan	5.1	93	78	4.4	31
Rienecker and Anderson (1960)	California	5.3	87	79	4.6	-
Hanson and Browning (1959)	Washington	5.4	92	71	5.1	-
Klopman (1958)	Manitoba	5.1	93	48	5.2	-
Steel et al. (1957)	Idaho	5.1	86	81	4.5	7
Craighead and Craighead (1949)	Wyoming	4.6	24	-	4.5	-
Dow (1943)	California	5.3	93	56	-	-
Williams and Marshall (1937)	Utah	4.8	81	-	4.7	-
Geis (1956)	Montana	5.4	85	62	4.9	20

[a]Estimated through five weeks following hatch.
[b]Percent of eggs hatched.
[c]Percent of nests with hatched eggs.

Thirty-three percent (41) of eggs observed in 1976 and 23% (38) in 1977 failed to hatch (Table 3). Infertility and desertion were the leading causes of egg failure. Flooding was not a factor leading to nest failure in 1976 but destroyed several nests in 1977.

Lengkeek (1973) and Bultsma (1976) found that 32% and 41%, respectively, of the eggs failed to hatch. The 9% infertility in 1976 and 14% in 1977 (Table 3) was similar to the 14% found by Lengkeek (1973) and 7% by Bultsma (1976). Mammalian predation and flooding were the leading causes of egg failure in their studies while infertility and desertion were the major causes in this study.

In studies from other parts of the North America (Table 2), percentage of eggs that hatched varied from 24% in Wyoming (Craighead and Craighead 1949) to 93% in Manitoba (Klopman 1958). Rienecker and Anderson (1960) in California found 12.7% of the eggs deserted; 7.1% destroyed by predators, and 1.5% of the nests lost to flooding. Hanson and Browning (1959) reported 11% of the nests deserted, 13% destroyed by predators, and 3% flooded.

Broods

Eighteen broods 1 to 14 days old were observed in 1976. In 1977, 30 broods 1 to 11 days old and 21 broods 2 to 5 weeks old were observed. Broods were aged according to the criteria set forth by Yocom and Harris (1965). Broods in the 1 to 14 day age-class in 1976 and 1 to 11 days in 1977 were used to compute brood size.

Table 3. Fate of eggs from known nests for giant Canada geese 1976-77 in western South Dakota.

	1976		1977		
	Number	Percent	Number	Percent	Total
Number of eggs	124	-	166	-	-
Number eggs successful	83	67	78	77	72
Number eggs failed	41	33	38	23	28
Eggs lost to:					
Predator	9	7.3	7	4.0	5.7
Flooding	-	-	5	3.0	3.0
Desertion	21	17.0	3	2.0	9.5
Infertility	11	8.9	23	14	11.5

Mean brood size was 4.6 $\pm$ 0.4 (S.E.) goslings in 1976 and 4.7 $\pm$ 0.2 (S.E.) in 1977 (Table 4). Lengkeek (1973) found a mean brood size of 4.4 goslings in 1970 and 4.7 in 1971 which was slightly higher than the 3.8 goslings per brood in 1974 and 4.5 in 1975 reported by Bultsma (1976). Brood sizes ranging from 4.3 to 5.5 goslings were reported for Canada geese in other parts of North America (Table 2).

Adult geese usually reared their young with several families of geese on a common stockpond. Williams and Marshall (1937) at Bear River, Utah, found that 75% of the broods occurred on three sites during the late brood season. Adult geese and their broods usually traveled 1 to 3 miles to a brood pond within 3 to 7 days after hatching. As a result the same broods could not be observed throughout their flightless period to determine mortality.

Gosling mortality was estimated from the decline in average brood size between broods 1 to 11 days old and broods 14 to 35 days old. In 1977 mean brood size declined from 4.7 goslings to 4.5 (4%). The decline was not significant ($P > 0.1$). Lengkeek (1973) found average gosling mortality of 10.8% in western South Dakota. Hanson and Eberhardt (1971) showed a 4% decrease in brood size during the first 14 days after hatching and an additional 10% decrease between between the 15 to 21 days. Kaminski and Parker (1975) reported a 25% decline in brood size by the end of the fourth week after hatching. Gosling mortality in other parts of North America varied from 7% to 31% (Table 2).

Table 4. Size of giant Canada goose broods observed in western South Dakota, 1976-77.

	1976[a]	1977[b]
Number of goslings	82	140
Number of broods	18	30
Mean brood size	4.6	4.7
Standard error	0.4	0.2

[a]Gosling 1-14 days old

[b]Gosling 1-11 days old

Population Estimates

Thirty pairs of territorial geese were observed on random sections in the 6 strata in 1976 (Table 5). Twenty-one (70%) pairs showed signs of nesting attempts and 16 (76%) nested successfully (hatching at least 1 gosling). Nesting success was 78% in 1971-72 (Lengkeek 1973) and 57% in 1974-75 (Bultsma 1976). Nesting success reported in other studies varied from 56% in California to 81% in Idaho (Table 2).

Estimated size of population for 6 strata in 1976 was 445 geese (0.4 geese per section) composed of 185 territorial pairs and 75 individuals (Table 5). One-hundred-thirty (70%) of the territorial pairs nested and 100 (76%) were successful. Based on an average brood size of 4.6 goslings, an estimated 460 goslings were produced (3.5 goslings per breeding pair).

In 1977, 74 territorial pairs of geese were observed on random sections (Table 6). Twenty-eight (41%) pairs showed signs of nesting of which 22 (79%) were successful.

The estimated population size for the entire study area in 1977 was 1196 geese (0.5 geese per section) composed of 573 territorial pairs and 50 individuals (Table 6). Two hundred thirty-six (41%) pairs nested and 184 pairs (79%) were successful. Based on an average brood size of 4.7 goslings an estimated 864 goslings were produced (3.7 goslings per breeding pair).

Table 5. Population size and production estimated from a random sample of nesting giant Canada geese for 6 strata (1016 sections) located in Haakon, Jackson, and Pennington counties, 1976.

	Numbers of Geese						
	Strata [a]						
	I	II	III	IV	V	VI	Total
Territorial pairs found:	9	7	7	1	3	3	30
Non-territorial geese found:	14	0	0	0	0	0	14
Nesting territorial pairs:	5	6	5	1	2	2	21
Nesting pairs successful:	4	4	4	1	1	2	16
Estimated size of population:[b]	177	82	93	13	40	40	445
Estimated number territorial pairs:	50	41	47	7	20	20	185
Estimated number pairs nesting:[c]	35	29	33	5	14	14	130
Estimated number nesting pairs successful:[d]	27	22	25	4	11	11	100
Estimated number goslings produced:[e]	124	101	115	18	51	51	460

[a]Eighteen percent of Strata I, 17% of Strata II, and 15% of Strata III, IV, V, and VI was sampled.
[b]Estimated number of territorial and non-territorial geese.
[c]Based on 70% of the observed territorial pairs nesting.
[d]Based on 76% nesting success.
[e]Based on average brood size of 4.6.

Table 6. Population size and production estimated from a stratified random sample of nesting giant Canada geese from 11 strata (2579 sections) located in Haakon, Jackson, and Pennington counties, 1977.

	Numbers of Geese											
	Strata [a]											
	I	II	III	IV	V	VI	A	B	C	D	E	Total
Territorial pairs found:	20	8	12	1	4	3	7	2	2	3	12	74
Non-territorial geese found:	2	7	0	0	0	0	0	0	0	0	0	9
Nesting territorial pairs:	4	2	3	-	3	1	3	1	1	3	7	28
Nesting pairs successful:	2	1	2	-	3	1	3	1	-	3	6	22
Pairs with unkown fate:	1	1	-	-	1	-	1	1	-	-	1	6
Estimated size of population:[b]	233	135	160	15	57	40	140	44	40	66	266	1196
Estimated number territorial pairs:	111	47	80	8	29	20	70	22	20	33	133	573
Estimated number pairs nesting:[c]	46	19	33	3	12	8	29	9	8	14	55	236

Table 6 (continued)

Estimated number nesting pairs successful:[d]	36	15	26	2	9	6	23	7	6	11	43	184
Estimated number goslings produced:[e]	169	71	122	9	42	28	108	33	28	52	202	864

[a]Eighteen percent of Strata I, 17% of Strata II, 15% of Strata III and Strata VI, 13% of Strata IV, 14% of Strata V, 10% of Strata A and C, and 9% of B, D and E was sampled.
[b]Estimated number of territorial and non-territorial geese.
[c]Based on 41% of the observed territorial pairs nesting.
[d]Based on 79% nesting success.
[e]Based on an average brood size of 4.7.

Habitat Characteristics

Stockponds on random sections in Stratum I were grouped according to the presence or absence of geese. An average of 2 stockponds per section was estimated for the study area. Twelve of the 53 randomly selected stockponds used by the geese had a mean size of 1.6 ha (4.4 acres); the smallest stockpond was 0.7 ha (1.4 acres). The 41 stockponds not used by geese averaged 0.6 ha (1.3 acres).

Fifty-four percent of the shoreline on stockponds used by geese was lined with vegetation while stockponds not used averaged 36% shoreline cover. Stockponds used by geese averaged 83% open surface water while stockponds not used by geese averaged 97%. Stockponds used by geese averaged 95% basin water and were not dry during summer while ponds with 75% basin water and usually dry in mid-summer were not used. Ponds used by nesting pairs averaged 22% headwater development and 1.5 peninsulas per stockpond while stockponds not used averaged 7.4% headwater development and 0.6 peninsulas. Both differences were significant ($P<.05$). Ninety-eight percent of all stockponds with an island were used.

Eighty-two percent of the nesting pairs used stockponds in sections comprised of more than 50% grassland (Table 7). Sixty percent of the sections in the study area were less than one-fourth cultivated (Table 8). Approximately 37% of the sections were between 25% and 75% cultivated. Only 3% of the sections were more than 75% cultivated. An increase in agriculture may restrict nesting activities by Canada geese in many areas.

Table 7. The relationship of landuse and the use of stockponds by pairs of nesting Canada geese on random sections.

Landuse (percent grassland)	Numbers of Observations of Canada Geese												
	Strata											Total	
	I	II	III	IV	V	VI	A	B	C	D	E	Number	Percent[a]
100-75	1	6	5	-	4	1	4	1	2	2	4	30	54
74-50	5	1	2	1	1	2	1	-	-	-	3	16	28
49-25	6	-	-	-	-	1	-	1	1	-	1	10	18
24-0	-	-	-	-	-	-	-	-	-	-	-	--	--

[a]Percent of total observations.

Table 8. Landuse measured as the percent area of each random section remaining as grassland and land ownership for the study area, 1977.

	Numbers of Random Four-Section Clusters											
	Strata											
Grassland (%)	I	II	III	IV	V	VI	A	B	C	D	E	Mean Percent
100-75	8 (22)[a]	26 (90)	18 (56)	8 (68)	5 (17)	7 (39)	33 (87)	18 (50)	13 (88)	21 (95)	15 (45)	60
74-50	12 (32)	2 (7)	11 (34)	2 (12)	13 (45)	5 (28)	4 (10)	11 (31)	1 (6)	1 (5)	14 (42)	23
49-25	12 (32)	1 (3)	3 (10)	2 (12)	9 (31)	5 (28)	1 (3)	5 (14)	1 (6)	–	3 (9)	14
24-0	5 (14)	– –	– –	– –	2 (7)	1 (5)	– –	2 (5)	– –	– –	1 (4)	3
Ownership												
Private	37 (100)	11 (38)	31 (97)	12 (100)	39 (100)	18 (100)	38 (100)	36 (100)	14 (93)	8 (47)	33 (100)	89
Public	– –	18 (62)	1 (3)	– –	– –	– –		1 (7)	9 (53)	– –	– –	11

[a]Percent

Eighty-nine percent of the study area was in private ownership (Table 8) and 11% was public land (National Grassland U. S. Forest Service, and leased school land). Ownership did not affect the use of stockponds by geese.

Stockponds with gently sloping shorelines and surrounding areas (0-15% slope) were used more frequently by nesting geese than stockponds with a steeper slope (30-50% slope) (Table 9). Stockponds with a maximum shoreline to horizon slope less than 16% were used significantly more ($P < .01$) than ponds exhibiting greater shoreline to horizon slopes.

It was estimated that 8.3% of the stockponds used by geese lay in a north-south direction; while 29.3% of the stockponds not used by geese fell into this category. The differences between direction of all stockponds measured were not significant ($P > 0.1$).

The use of stockponds by livestock had a negative influence on the presence of geese (Table 10). Ninety-three percent of the giant Canada goose observations in the study area were associated with stockponds with low to moderate disturbance by livestock. Heavily disturbed stockponds accounted for only 7% of the observations.

The average distance from farms to stockponds was 1.9 km for ponds used by geese and ponds not used was 1.4 km the difference was not significant ($P < 0.05$). Geese were often observed nesting on ponds adjacent to farm buildings.

Table 9. The occurrence of nesting pairs in relation to maximum shoreline to horizon slope determined from stockponds on random sections in the study area, 1977.

	Number of Observations of Geese												
	Strata												
Percent Slope	I	II	III	IV	V	VI	A	B	C	D	E	Total	Percent
0-15	9	5	6	1	4	3	–	2	2	–	4	36	64
16-30	3	1	1	–	1	1	4	–	–	2	3	16	29
31-50	–	1	–	–	–	–	1	–	1	–	1	4	7
over 50	–	–	–	–	–	–	–	–	–	–	–	–	–

Table 10. The relationship between livestock disturbance and the use of stockponds by nesting pairs of giant Canada geese.

Levels of Disturbance	Number of Observations of Canada Geese												
	Strata												
	I	II	III	IV	V	VI	A	B	C	D	E	Total	Percent
Low	5	4	5	-	4	2	-	1	-	-	-	21	38
Moderate	5	3	2	1	1	2	5	1	3	2	6	31	55
Heavy	2	-	-	-	-	-	-	-	-	-	2	4	7

Analysis of Habitat

Data measured for each stockpond were analyzed using a stepwise discriminant function analysis program (Nie et al. 1975). Klebenow (1969) used the stepwise discriminant function analysis to assign habitat as suitable or not suitable for sage grouse (*Centrocercus urophasianus*). Crawford and Bolen (1976) used a stepwise multiple regression analysis to evaluate the impact of landuse on lesser prairie chickens (*Tympanuchus pallidicinctus*) in Texas. James (1971) and Kaminski and Prince (1977) indicated that the discriminant function analysis quantitatively evaluated nesting habitat and revealed species-specific nest site preferences.

Nesting habitat data were analyzed in the following 5 manners: (1) all variables except class were entered and groups consisted of stockponds with and without geese; (2) the 5 top-ranked variables were used and groups remained the same; (3) the 7 top-ranked variables were used and groups remained the same; (4) all variables were used but groups consisted of 4 habitat classes (1-4) one of which was assigned to a stockpond based on the quality of the stockpond as nesting habitat determined from the variables measured and my judgement; and (5) all variables including class were used and groups consisted of stockponds with or without geese.

Variables which had the highest discriminating capabilities were selected and ranked by the computer in the first analysis (Table 11). This analysis showed that 64% of the variation

Table 11. The relative percentage of variation explained by 13 variables selected by the computer in the discriminant function analysis.

Variable	Wilks' Lambda[a]	Percent Variation Explained	Total Variation Explained
SIZE	.69569	30.4[c]	30.4
HEAD	.60122	9.4[c]	39.8
ISLAND	.55412	4.8[c]	44.6
PERPD2	.51954	3.4[c]	48.0
COW	.48238	3.7[c]	51.7
MAHOSL	.46463	1.8	53.5
SHVH	.44886	1.6	55.1
MIHOSL	.43641	1.2	56.3
MISHSL	.42185	1.5	57.8
SIZE[b]	.43029	-2.0	55.8
SEAST	.41709	0.5	58.3
HEAD[b]	.42167	-1.1	57.2
WEST	.39234	2.4	60.7
MASHSL	.37717	1.6	62.3
MAN	.36039	1.7	64.0

[a]Proportion of variation unexplained after incorporating the variable.
[b]SIZE and HEAD were removed in Steps 10 and 12 of the stepwise discriminant analysis.
[c]Significant change ($P < .05$).

between stockponds used by geese and stockponds not used by geese was explained by 13 variables. A significant ($P < .01$) portion of the variation that existed between the 2 groups of stockponds was not explained. Size, headwater development, presence of an island, permanence of the stockpond, and disturbance by livestock explained significant ($P < .05$) portions of the variation (Table 11). Variations of the other 8 variables were not significant and only explained 12.3% of the variation. The percent of variation explained by each variable in Table 11 remained constant in the second and third analysis.

Using the above 13 variables the computer correctly predicted the presence of geese and absence of geese on stockponds 83.3% and 97.6% of the time, respectively (Table 12). An average of 94.3% accuracy was achieved. The variable or combination of variables which yielded the highest accuracy represented the physical characteristics of each stockpond that influenced its use or nonuse by nesting geese.

The purpose of the second analysis was to measure how accurately the 5 significant variables in Table 11 could predict the use or nonuse of stockponds by geese. The accuracy of the computer to predict the presence of geese on the stockpond dropped to 66.7% while prediction of the absence of geese remained the same (Table 12). An overall 90.6% accuracy resulted.

Table 12. Presence or absence of giant Canada geese on stockponds predicted by the computer based on the number of variables considered in three different discriminant analyses.

		Predicted Memberships (stockponds)				
		Geese Present		Geese Absent		
Actual Membership (stockponds)	Number	Number	Percent	Number	Percent	Total
All variables:						
Geese present	12	10	83.3	2	16.7	94.3
Geese absent	41	1	2.4	40	97.6	
Five top-ranked variables:						
Geese present	12	8	66.7	4	33.3	90.6
Geese absent	41	1	2.4	40	97.6	
Seven top-ranked variables:						
Geese present	12	9	75.0	3	25.0	94.3
Geese absent	41	0	0.0	41	100.0	

The variables, shoreline to horizon maximum slope and shoreline vegetation height were added to the previous 5 variables to measure efficiency gained by using the next 2 important discriminating variables. The variable maximum shoreline to horizon slope was more important than minimum slope because after the slope increased to a certain point the usage of a stockpond by geese decreased. Seventy-five percent of the stockponds used by geese and 100% of the stockponds not used were correctly classified as such by the computer when the 7 variables were considered. The results from the 3 analyses indicated that the use of stockponds by geese could be predicted with reasonable accuracy.

All variables were entered into the discriminant function analysis to determine which variables best discriminated between the 4 habitat classes of stockponds. The findings indicated that the 13 variables in Table 13 influenced my decision when I assigned each stockpond to a specific habitat class. Size and headwater development together explained 55% of the variation between the 4 classes of stockponds.

The classification portion of the above analysis indicated that I correctly assigned 100% of Class 4 stockponds, 80% of the Class 3, 78% of Class 2, and 92% of Class 1 ponds into the proper category (Table 14).

When the class of each stockpond was entered into the analysis as a separate variable with the other 30 variables,

Table 13. The contributions of 19 variables used to discriminate between the 4 habitat classes of stockponds to determine consistency of assigning stockponds to one of the 4 classes.

Variable	Wilks' Lambda	Percent Variance Explained	Total Variance Explained	Functions Derived	Relative Percentage[a]
SIZE	.65091	34.9	34.9	1	64.1[b]
HEAD	.44316	20.8	55.7	2	25.1[b]
BASIN	.35989	8.3	64.0	3	10.8
SUVD	.30131	5.9	69.9		
DTFM	.26489	3.6	73.5		
SOUTH	.21348	5.1	78.6		
SEAST	.18707	2.6	81.2		
EAST	.16568	2.1	83.3		
PENN	.14918	1.7	85.0		
SHEM	.13702	1.2	86.2		
ISLD	.11999	1.7	87.9		
OPEN	.10886	1.1	89.0		
NOWT	.09660	1.2	90.2		
SWEST	.08324	1.3	91.5		
MIHOSL	.07569	0.7	92.2		
SULU	.06804	0.8	93.0		
MAHOSL	.05873	0.9	93.9		
NORTH	.05056	0.5	94.4		
SUVH	.04901	0.7	95.1		

[a]Percent of unexplained variation in the discriminating variables explained by that function.
[b]$P > .001$

class became the most important variable to discriminate between the presence or absence of geese on a stockpond (Table 15). The variables island, eastward drainage, and northward drainage were respectively ranked second through fourth. The other variables did not offer additional information and were thus omitted from the analysis by the computer. The 4 variables accounted for 65.1% of the variation between the two groups of ponds while class explained 49.4%. The variable class summarized much of the information present in the other 27 variables.

The computer correctly predicted the presence of geese and absence of geese on stockponds with 91.7% and 92.7% accuracy, respectively, when class was considered (Table 16). In this study, both the use and nonuse of stockponds by geese were most accurately predicted when class was used in conjunction with the other variables. These results showed the importance of some techniques, such as class, to evaluate the entire environment of a stockpond to estimate its suitability as goose nesting habitat.

There was a significant ($P < .05$) difference in the number of stockponds used by geese between the 4 habitat classes (Table 17). The percentage of stockponds used increased from 1% in Class 1 to 93% in Class 4. As the population of geese expands, it is expected that higher percentages of Class 2 and Class 3 ponds will be used.

Table 14. The prediction results from the fourth analysis where each stockpond was assigned to a habitat class by the computer based on the variables measured.

		Predicted Membership (stockpond)								
		Number Class				Percent Class				
Actual Membership (class)	Number	1	2	3	4	1	2	3	4	Total
1	24	22	2	0	0	91.7	8.3	0	0	84.91
2	18	3	14	1	0	16.7	77.8	5.6	0	
3	10	0	2	8	0	0	20.0	80.0	0	
4	1	0	0	0	1	0	0	0	100	

Table 15. The percentage of total variation between stockponds with giant Canada geese and stockponds without giant Canada geese explained by each discriminating variable when class was entered into the discriminate function analysis.

Variables	Wilks' Lambda[a]	Percent Variation Explained	Total Variation Explained
CLASS	.50624	49.4[b]	49.4
ISLD	.37942	12.7[b]	62.1
EAST	.36576	1.4	63.5
NORTH	.34940	1.6	65.1

[a]Proportion of variation unexplained
[b]Significant ($P<.001$)

Table 16. Presence and absence of giant Canada geese on stockponds predicted by the computer when class was entered as an additional variable.

Actual Membership (stockponds)	Number	Predicted Memberships (stockponds)				Total
		Geese Present		Geese Absent		
		Number	Percent	Number	Percent	
Geese present	12	11	91.7	1	8.3	92.45
Geese absent	41	3	7.3	38	92.7	

Table 17. Utilization of stockponds by giant Canada geese determined for each class of stockponds, 1977.

	Numbers of Stockponds											
	Strata											
Ratings	I	II	III	IV	V	VI	A	B	C	D	E	Percent[d] Usage
Class 1	25[a]	17	15	6	14	13	17	12	19	10	19	
	–[b]	–	–	–	–	–	–	–	1	–	1	
	–[c]	–	–	–	–	–	–	–	(5)	–	(5)	1.0
Class 2	17	10	11	4	7	6	3	7	4	6	13	
	3	3	–	–	–	3	–	–	–	1	–	
	(18)	(30)	–	–	–	(50)	–	–	–	(17)	–	11.0
Class 3	10	3	14	3	11	2	5	5	1	–	8	
	8	2	6	1	5	1	5	1	1	–	4	
	(80)	(67)	(43)	(33)	(45)	(50)	(100)	(20)	(100)	–	(50)	59.0
Class 4	1	2	2	–	–	–	–	1	1	1	3	
	1	2	1	–	–	–	–	1	1	1	3	
	(100)	(100)	(50)	–	–	–	–	(100)	(100)	(100)	(100)	93.0

[a]Number stockponds in that class
[b]Number of stockponds used by geese
[c]Percent of stockponds in that class and strata used by geese
[d]Each total was significantly different ($P<0.05$)

The number of stockponds in each habitat class was estimated for the study area (Table 18). A total of 2674 stockponds was estimated in the four habitat classes.

A potential population size of 1287 nesting pairs of geese was estimated for the study area providing that all stockponds in Class 2 through Class 4 would be used by at least 1 pair of geese. However, the future size of the population will be determined by factors such as intraspecific tolerances of the geese, landowner tolerances, or management decisions.

Table 18. Estimated number of stockponds in the 4 classes used to rate giant Canada goose nesting habitat for the study area (11 strata), 1977.

	Numbers of Stockponds											
	Strata											
Observed Stockponds	I	II	III	IV	V	VI	A	B	C	D	E	Total
Class 1	25 (46)[a]	17 (53)	15 (36)	6 (46)	14 (44)	13 (62)	17 (68)	12 (48)	19 (76)	10 (59)	19 (44)	167 (51)
Class 2	17 (31)	10 (31)	11 (26)	4 (31)	7 (22)	6 (29)	3 (12)	7 (28)	4 (16)	6 (35)	13 (30)	88 (27)
Class 3	10 (19)	3 (9)	14 (33)	3 (22)	11 (34)	2 (9)	5 (20)	5 (20)	1 (4)	– –	8 (19)	62 (19)
Class 4	1 (4)	2 (7)	2 (5)	– –	– –	– –	– –	1 (4)	1 (4)	1 (6)	3 (7)	11 (3)
Estimated Stockponds[b]												
Class 1	139	100	100	46	100	87	170	133	190	111	211	1387
Class 2	94	59	73	31	50	40	30	77	40	67	144	705
Class 3	56	17	93	23	79	13	50	56	10	–	89	486
Class 4	6	12	13	–	–	–	–	11	10	11	33	96
Total	295	188	279	100	229	140	250	277	250	189	477	2674

[a]Percent of total ponds observed in that strata.
[b]Eighteen percent of Strata I, 17% of Strata II, 15% of Strata III, and Strata VI, 13% of Strata IV, 14% of Strata V, 10% of Strata A and C, and 9% of B, D, and E was sampled.

CONCLUSION

Number of geese increased from 0.4 geese per section in 1976 to 0.5 geese in 1977 with a decline in the number of goslings produced in 1977. Lower production in 1977 was the result of a decrease in number of territorial pairs that nested and a lower percentage of successful nests.

Large, permanent stockponds with emergent vegetation and gentle sloping shorelines were most frequently used by breeding pairs of geese for nesting purposes. There was a preference for stockponds that contained peninsulas or islands.

The presence and absence of geese on a stockpond were most accurately predicted when "class", a numerical habitat rating assigned to each stockpond, was entered into the analysis as a variable. When class was omitted, size, headwater development, presence of an island, permanence of the stockpond, livestock disturbance, maximum shoreline to horizon slope, and shoreline vegetation height became the most important discriminating variables. These five variables explained 55% of the variation between stockponds used by geese and ponds not used while class explained 49.4%.

I estimated that the study area was capable of supporting a breeding population of 1287 pairs of geese based on 1 pair per stockpond. Stockponds belonging to Class 1 were not considered as suitable nesting habitat for giant Canada geese.

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